

Seeds for Rootstocks of Fruit and Nut Trees

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THE PRINCIPAL fruit and nut trees grown commercially in the United States (except figs, tung, and filberts) are grown as varieties or clonal lines propagated on rootstocks.

Almost all the rootstocks are grown from seed. The resulting seedlings then are either budded or grafted with propagating wood of the desired variety. This practice has come about chiefly because the improved varieties of these fruits and nuts do not come true from seed and are not easily propagated on their own roots from cuttings.

Seedlings used for rootstocks generally are easy to grow. Experience has taught us which scion-rootstock combinations are suitable and how to produce good nursery trees.

Growing fruit and nut trees on rootstocks rather than on their own roots has many advantages.

Some of the desirable horticultural varieties have more vigor when they are grown on vigorous rootstocks. Some varieties on their own roots are susceptible to root-infecting, disease-causing organisms and nematodes, root- and crown-infesting insects. Some are intolerant to salt, drought, alkali, and poorly drained soils. The cold hardiness of some varieties can be increased by topworking them onto the framework of cold-hardy varieties.

Many varieties produce fruit of better quality and are more productive on suitable rootstocks than they are on their own roots. By a choice of rootstocks, some fruit and nut crops can be grown in areas otherwise not suitable.

In instances where rootstocks have solved problems for one crop, their use has led to calamity in another.

An example is the sour orange. Because of its adaptability to heavy soils, resistance to foot rot, relatively high resistance to cold, and production of good crops, the sour orange has become widely used throughout the world as a rootstock for sweet oranges.

The tristeza virus, which destroys sweet orange trees growing on sour orange roots, got a foothold in South America. It spread and killed millions of trees and almost wiped out the industry. The tristeza virus has now become universal there, and the industry is being reestablished only by the use of tolerant rootstocks, such as Cleopatra mandarin, sweet orange, Rangpur lime, and rough lemon.

Many factors, some of which are changing continuously, determine the suitability of rootstocks. Likewise, new information is being developed constantly, and new and better rootstocks become available to meet the need.

A GOOD ROOTSTOCK is one on which the desired variety of fruit or nut makes a good graft union and on which it is long lived, yields well, grows relatively fast, and fruits early. It must be reasonably compatible with the top variety.

If the rootstock variety is vigorous and the top variety is thoroughly compatible on it, the resulting tree tends to grow fast, is large, and often comes into fruit late. Such overvigorous combinations sometimes result in reduced quality or yield of fruit.

On the other hand, when the rootstock and top are not thoroughly compatible, the tree is likely to be dwarfed. Such incompatibility is often the result of failure of suitable formation or function of the phloem at or near the bud union. The phloem is the tissue that contains the food-conducting tubes in the bark through which the elaborated food made in the leaves flows to the roots to nourish them. Because of reduced nutrition, the roots are dwarfed,

and there is a corresponding dwarfing of the tops.

The reduced function of the phloem at the bud union leads to an accumulation of elaborated food in the tops, that in turn causes earlier maturation of fruiting wood and earlier fruiting.

Nurserymen have made use of such partial incompatibility directly or with interstocks to produce dwarf trees, which fruit correspondingly at an earlier age.

Other desirable features claimed for dwarfed trees are cheaper and easier control of pests; lower cost of pruning, thinning, and harvesting; and higher quality and better color of fruit.

The problem in producing dwarf trees is to find combinations that allow enough of the normal functions to go on so that the trees will have the desired size; not be subject to winter injury, malnutrition, and disease; and be productive of good fruit.

A ROOTSTOCK seed parent should produce seedlings that are uniform in size, vigor, and the qualities which make a seedling a good rootstock.

Preferably a rootstock seed parent should be self-fertile so that it can be grown in isolated blocks and thereby prevent hybridization and variability in the seedlings. The fruits and seeds should all mature at the same season to permit machine harvesting. If the seeds are in fleshy fruits (such as cherries and plums), the fruit should be a freestone to allow easier removal of the fruit flesh.

The trees that are sources of seed should be productive. The seeds should give a high percentage of germination.

THE SEEDS of fruit-tree rootstocks have to be harvested, stored, and handled in different ways.

Some cannot be dried or allowed to ferment in the juice of the fruit. Some need afterripening before they will germinate. Some remain viable in a dry condition for several years.

Because citrus seed soon loses its vitality if it becomes too dry, it is

usually extracted from fresh fruit by hand, washed free of pulp and juice, surface dried, and planted immediately. If it is to be stored, the washed seed should be dipped in a 1-percent solution of 8-oxyquinoline sulfate, surface dried, and placed in a polyethylene plastic bag and kept in cold storage at 38°-40° F. Such treated citrus seed can be stored many months with only a slight decline in viability.

SEEDS of peach, apricot, cherry, and plum should be extracted from fresh fruit and preferably washed free of fruit parts and juice as soon as possible. These stone-fruit seeds lose their ability to germinate if they are allowed to ferment in fruit juice or fruit pomace. Viability is severely reduced if left in fermenting juice even for 24 hours. On the other hand, properly dried and cured seeds of peach, plums, and apricot may be kept 4 years or more in a cool, dry storage with little loss in viability.

Cherry seeds generally are more sensitive to drying. After harvest they should be thoroughly washed, surface dried, and kept in a cool, moist storage until they are ready for planting or placed in storage for afterripening. In some sections, cherry rootstock seeds are planted directly in the nursery in the fall. Some growers prefer to hold them in a mixture of moist peat and sand in a cold storage and plant them in the spring. Cherries need approximately 110 to 120 days at 40° for best germination.

Mazzard and mahaleb cherries are the commonest rootstocks for sweet cherries. Some cherries are grown exclusively on mahaleb. Seeds of both mahaleb and mazzard do not remain viable as long as peaches and apricots.

Seeds of apple, pear, and quince mainly are harvested from local varieties at processing plants, washed, surface dried, and stored in cool, moist storage. Sometimes they are planted immediately directly in the nursery row.

Almonds can be air dried. They will

retain their viability for several years in common dry storage.

Pecan seeds are harvested and planted immediately in the fall or they can be stratified in moist sand until they germinate when they are planted in the nursery row.

No entirely satisfactory rootstock has been found for the Regia or Persian walnuts. *Juglans hindsii*, the northern California black walnut, Regia seedlings, and Royal and Paradox hybrids are all used. The seed is stored over winter in a cool, moist place and planted in the spring.

MANY TREE seeds need a rest or afterripening period before they will germinate.

Generally speaking, seeds with a hard shell or pit require more rest than those with a softer shell or without a shell.

Most soft or fleshy seeds that do not stand drying usually will grow almost immediately as soon as they are put in a suitable environment for germination.

Most seeds acquire their needed rest period or chilling requirement only when placed under proper environment. Most varieties of peach need 100 to 120 days in a moist substrate, such as a mixture of moist peat and sand at 40°, to give maximum germination.

A few seeds will germinate after 60 days, and the percentage increases with time. Peach seeds can be held at 32° for several months after their rest period has been satisfied without germination, but will germinate immediately if the temperature is raised.

Moisture is as important as cold in the afterripening process. Most deciduous seeds in temperate climates will receive more rest than they need if they are planted directly in the nursery row and allowed to obtain their chilling from natural exposure. Freezing is not necessary but usually is not harmful unless it is severe.

Apricots, almonds, cherries, and plums can be afterripened in the same way as peaches.

Some plums, especially *domestica*

species, require much more chilling than most peaches. The myrobalan plum, *Prunus cerasifera*, requires about the same chilling as peaches.

Mahaleb cherries require slightly more than peaches, up to 125 days, and some mazzard cherries may require even more.

Apricots and almonds require only 50 to 60 days for afterripening.

Pears and apples require only 6 weeks or less.

In general, the seeds cannot be dried after they have had their rest period without losing their viability.

Seeds of some fruits, such as peaches and cherries, will continue to grow if removed from fruits at maturity and placed in a proper environment without drying. No chilling is needed for such seed unless they are allowed to stop growing, in which case they will require chilling before growth is resumed.

FEW DISEASES are spread in or on seeds used for rootstocks. Most important are virus diseases.

No viruses are known to be carried in citrus seeds, although most of the commercial citrus trees throughout the world are infected with virus. Some of the viruses, like psorosis, produce violent and devastating symptoms. Others are latent unless the variety is topworked on a sensitive rootstock. Citrus varieties and species that produce asexual seeds can be reconstituted free of virus by merely growing seedlings, which are propagated.

The prunus ring spot virus can pass from parent through seeds to seedling in peach, cherry, and certain plums. Very likely it is seed-transmitted in other species. It also may be spread to seedling progenies of virus-free trees that are pollinated with pollen from infected trees. The viruses of peach necrotic leaf spot, prune dwarf, and sour cherry yellows are transmitted in peach and cherry seeds.

Several bacterial diseases are spread on rootstock seeds. The crown gall organism, *Agrobacterium tumefaciens*, is

widely present in many soils and is carried in water. Seeds that are allowed to come in contact with contaminated water will carry the organism with them. The crown gall organism, a wound parasite, commonly infects young seedlings whose cotyledons are torn as they emerge from the seedcoat. Incipient infections develop with the seedling and often form large galls at the crown. *Prunus* seeds also can become contaminated with the organism that causes bacterial canker, *Pseudomonas syringae*.

THE CLIMATE, soils, salinity of water, pests, diseases, and conditions under which citrus is grown are so varied that no one rootstock is satisfactory for all citrus trees.

The various kinds of citrus respond differently on the same rootstock. Some grow better on one, and others on another. The adaptability of sour orange to heavy soils, its resistance to foot rot, and production of good crops of high-quality fruit has made it a first choice in many areas for oranges and grapefruit. Where tristeza virus has become established, however, it cannot be grown.

Rough lemon produces large trees with good yields on the light, sandy, ridge sections of central Florida and in many other areas with similar soils and climates. It is tolerant to tristeza. It is about as susceptible to foot rot as sweet orange and produces fruit with low solids.

Citrus macrophylla is the most tolerant of boron of any citrus rootstock and produces good crops of lemons in high-boron soils, but it is only moderately tolerant to chlorides and is tender to cold.

The trifoliate orange, *Poncirus trifoliata*, is deciduous and sufficiently hardy that it will grow as far north as Boston. It is not deciduous in warm climates and is only slightly more cold hardy than sour orange. Sweet oranges and certain mandarins grow well on it and produce good crops if they are free of the exocortis and other viruses that

stunt trees on it. It is salt sensitive and therefore cannot be used on salty soils.

Rangpur lime has proved to be a good rootstock, well adapted to the soils and climates of some areas, but is severely damaged if the top variety is infected with the rangpur lime disease virus—a virus related to exocortis.

Cleopatra mandarin is a good prospect for replacing sour orange because of its tolerance to foot rot and tristeza, its reasonable adaptability to heavy soils, its salt tolerance, and its ability to produce good quality in grapefruit and sweet orange. In some sections, trees on it are slow to come into bearing and do not grow so rapidly or bear so heavily as on some of the other rootstocks.

Some of the citranges (trifoliate \times orange hybrids), such as Troyer, have shown excellent promise in some areas, but, like its trifoliate parent, is salt sensitive. Carrizo citrange has shown resistance to the burrowing nematode in Florida. Other selections and hybrids of trifoliata have shown resistance to the citrus nematode.

Citrus is somewhat by itself with respect to rootstocks because of the large number of distinct genera on which it will grow and the striking responses a single variety will produce when grown on closely related species and varieties.

Through hybridization, new rootstocks can be tailored for individual varieties, soils, and resistance to pests. Extensive work to develop better stocks is underway in Florida, Texas, and California.

Most of the seed used for citrus rootstocks in the United States is obtained from trees grown specifically for seed production. Growers specify varieties—even individual strains of varieties—that they know will give good uniformity, vigor, and performance.

STONE FRUITS show considerable mutual grafting affinities, but many combinations are not satisfactory for commercial use.

Peach is used widely as a commercial rootstock for apricots, plums, almonds,

and some other *Prunus* species. Peach, however, does not do well when the combination is reversed and it is grown as the top on rootstocks other than peach.

Seedlings of the Lovell peach are the commonest rootstock used for peach. Seedlings of Muir also have been widely used but have become hard to get. The wide use of these varieties is due partly to availability of seeds. Because both varieties have been used for drying and for jam, seed is saved easily and dried at the time of processing. Lovell seedlings are preferred by nurserymen over other varieties because they are more uniform, less bushy, and easier to bud.

Peach nursery stock used to be grown almost exclusively on Tennessee or Carolina naturals—escaped semiwild peaches, which descended from seed introduced by early Spanish settlers in the Southeastern States. Because of lower cost, ample supply, and good performance, Lovell has largely supplanted naturals as a source of seed.

The increasing recognition of damage to trees on peach rootstock by nematodes, particularly the root knot nematodes, has heightened interest in nematode tolerant stocks. Bokhara, Yunan, and Shalil, introduced from China and India in the 1920's, showed some resistance to the root knot nematodes, but seedlings have had variable amounts of infection. Orchards on some selections of Shalil have been severely damaged by crown rot in California.

Several nematode-resistant peach rootstocks have been introduced. Stribling's Nursery at Merced, Calif., introduced a patented variety under the name S-37. The Del Rancho Fortuna Nursery at Delano, Calif., introduced Rancho Resistant in 1956. The Department of Agriculture released FV-234-1 for trial in 1959.

S-37 has proved to be more resistant than Shalil, Bokhara, or Yunan, but it segregates in resistance and growth habit. Some seedlings are weak and weeping in habit.

Rancho Resistant appears to be resistant to the *acrita* strain of the root knot nematode but not to *javanica*.

The heritage of FV-234-1 is unknown. It was selected by J. H. Weinberger at Fort Valley, Ga., from seedlings from a lot of seed obtained from an importer as *Prunus davidiana*. As it resembles a true peach, it may be a hybrid. It is resistant to the *acrita* strain, but about one-fourth of the seedlings develop small galls when exposed to *javanica*. We have no evidence, however, that *javanica* is able to reproduce on them.

There is a growing demand for nematode-resistant and virus-free seed stocks of peach. To supply the demand, orchards are being planted specifically for seed production. Seeds from them very likely will replace the seeds that have been available as a byproduct of processing industries.

The viability of peach seeds varies from year to year. We do not know why. Seed lots with high viability retain their viability if kept dry for several years. Some nurserymen hold over and use seed from such good germination years in order to assure good stands of seedlings.

Peaches have never been successful commercially on rootstocks other than peach. They are more compatible with apricot than with plums and almonds. Before nematode-resistant peach rootstocks were available, some peach orchards were grown on apricot rootstock. Such trees were somewhat dwarfed and were generally shorter lived than on peach.

Peaches grown on certain strains of St. Julien and Damson plums are more dwarfed and shorter lived than on apricot.

Dwarf peaches are standard varieties grown on the sandplum, *Prunus besseyi*.

PLUMS are less demanding than peaches as to rootstocks. Most plums appear to do well on peach as a rootstock. About 50 percent of the commercially grown plums are on peach.

The European plums seem to be less

suited to peach than the Japanese. Imperial prune appears to be more resistant to bacterial gummosis on peach than on myrobalan plum.

French prune tends to bear earlier and produce larger fruit on peaches than on myrobalan. Italian prune in the Pacific Northwest is commonly grown on peach rootstock.

Plums will also grow on almond and apricot rootstocks. A number of French prune orchards are on apricot roots. A few varieties of plum, such as Beauty, Gaviota, El Dorado, and Duarte, make weaker unions on apricot than on peach. Some plums have trouble on almond roots.

Myrobalan and marianna plums, *P. cerasifera*, are widely used as rootstocks for plums. The most of the myrobalan is propagated from domestic or imported seed. Some orchards are grown on myrobalan 29C selected in California, a vegetatively propagated myrobalan clone that is tolerant to nematodes and armillaria root rot. Marianna 2624, a similarly vegetatively propagated clone, also developed in California, is gaining favor.

ABOUT HALF of the apricots and almonds are grown on peach rootstock. The rest are on seedling apricot and almond, respectively. Seed of Royal or Blenheim from fruit-drying yards are the commonest sources of apricot seedlings.

Formerly the seeds of the bitter almond, commonly used as a pollinizer in almond orchards, was used as a source of seeds for almond rootstock, but the variety Texas probably is most commonly used now.

Almond is losing favor as a rootstock for almonds in heavy and poorly drained soils because they appear to be more susceptible than peach to crown rot.

SWEET AND SOUR cherries are grown chiefly on mahaleb, *P. mahaleb*. Mazzard, *P. avium*, is preferred in some areas.

The seeds of mahaleb are harvested

from seedling orchards grown entirely for seed purposes. New varieties, known as Russian and Turkish mahaleb, have been tested and have proved to be more vigorous and winter hardy and appear very promising.

Mazzard seeds used to be obtained from pollinator trees in western orchards and from wild native trees in the eastern States. Improved strains of the so-called "silver bark" mazzards, imported from Germany by the Geneva branch of the New York Agricultural Experiment Station, appear promising. Because the ring spot, sour cherry yellows, and prune dwarf viruses are seedborne, scientists began work to establish virus-free orchards as sources of seed. Some seed of both rootstocks still are imported from Europe.

MOST OF the apples in the United States formerly were propagated on French crab, a cider apple grown in France. More recently, seedlings of domestic varieties, such as Delicious, Winesap, Jonathan, Rome Beauty, and York, have become widely used.

In places subject to low winter temperatures and sudden drops in temperatures, the practice of double working to produce trees with cold-hardy trunks is increasing. The use of partially incompatible trunk sandwiches—interstocks between the variety top and the seedling rootstock—to produce dwarf trees has become popular, but most dwarf trees are produced by growing varieties directly on dwarfing stocks, like the East Malling and Malling Merton series. Apples are grown commercially only on apple rootstocks and appear to grow equally well on seedlings of most commercial varieties.

PEARS are grown mostly on domestic Bartlett seedlings. The early pear plantings in the United States were almost entirely on French pear seedlings. Since 1920 or so, most of the pear stock was grown on oriental pear understock from seed brought from

Asia. They produced vigorous trees, and were liked in the nursery because of some resistance to fire blight and woolly root aphid and freedom from leaf troubles. The association of hard end and black end of the fruit with oriental rootstock discouraged their use, and no oriental stock is used in the commercial pear orchards of western States.

PEAR DECLINE, a new disorder that has devastated pear orchards in the western States, has been associated with oriental rootstocks and has brought about renewed interest in pear rootstocks.

The Angers quince propagated vegetatively is used as a dwarfing stock for pears, but there is wide variation in behavior of varieties grown directly on quince. Bartlett normally does not do well on quince. In areas where blight is bad, blight-susceptible pears are grown on trees composed of seedling roots, Old Home, or other blight-resistant variety trunks on which the desired varieties have been top-worked. If planted deep, the Old Home often forms roots above the bud union with the original seedling.

The Persian walnut, *Juglans regia*, is grown mostly on the northern California black walnut, *J. hindsii*. Regia seedlings, Royal and Paradox hybrids (*J. hindsii* × *J. nigra*), and (*J. hindsii* × *regia*) have been gaining in popularity because of black line, a disorder in which the bark dies at the bud union on trees of Persian on *J. hindsii*. Regia and its hybrids appear to be more resistant to the meadow nematodes.

PECANS are grown almost entirely on domestic pecan seedling rootstocks. Seed from scab-resistant varieties with medium-size nuts, such as Curtis and Stuart, are preferred, because the seedlings in the nursery are less affected by scab and make more vigorous trees.

The small, native western nuts produced out of the heavy scab area are apt to be highly susceptible to scab and should be avoided.

TUNG is grown mostly as seedlings directly on their own roots. Seed should be collected as first-generation seed from clonally propagated varieties that have progeny performance records as to production, oil yield, vigor, and cold hardiness. Seedlings of Folsom, Lampton, and LaCrosses come true to the parent type. Lampton is probably the most widely used seed parent.

Filberts are grown from layered cuttings and thus are on their own roots. Trees are mounded and new plants are obtained from the suckers that grow from the base of the tree and root in the mound.

Figs are nearly all grown on their own roots. Cuttings are made of dormant 1- to 3-year-old wood, which is buried until it is well calloused. Then it is planted in the nursery row and later in the orchard. Some varieties have shown greater vigor and nematode resistance and are used as rootstocks for other varieties.

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